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# The Effects of Bonuses on Army Reserve Reenlistments: An Empirical Bayes Approach

Charles Dale

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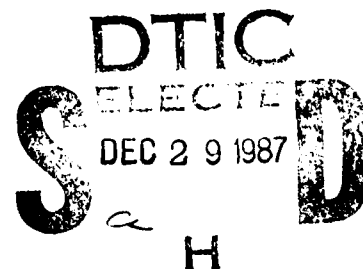Manpower and Personnel Policy Research Group
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20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

    The President's Sixth Quadrennial Review of Military Compensation placed special emphasis on reserve compensation. This paper was written in support of the Sixth QRMC. Empirical Bayes estimation techniques have been especially useful in applications where existing data bases have been small or incomplete. An empirical Bayes analysis of Army Reserve reenlistment data showed that bonuses increased committed man-years of service and that 6-year bonuses are most cost-effective than 3-year bonuses.

# The Effects of Bonuses on
# Army Reserve Reenlistments:
# An Empirical Bayes Approach

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Manpower and Personnel

The Manpower and Personnel Policy Research Group of the U.S. Army Research Institute (ARI) performs research in the economics of manpower, personnel, and training issues of particular significance to the U.S. Army. Questions about the cost effectiveness of reenlistment bonuses have generated continuing interest.

Every 4 years the President establishes a Quadrennial Review of Military Compensation (QRMC) to study important military compensation issues. The Sixth QRMC has placed special emphasis on reserve compensation. This report was prepared as part of the Program Task in Recruiting and Retention of the ARI Manpower and Personnel Laboratory, under the 17 July 1987 memorandum from the Staff Director of the Sixth QRMC to the Commander of the Army Research Institute. In August 1987 the results of the report were briefed to the Sixth QRMC, which concurred with its findings. The ideas developed in this report have been used by the Sixth QRMC as part of its examination of the relative effectiveness of reserve incentive programs.

EDGAR M. JOHNSON
Technical Director

THE EFFECTS OF BONUSES ON ARMY RESERVE REENLISTMENTS: AN EMPIRICAL BAYES
APPROACH

EXECUTIVE SUMMARY


Requirement:

     The U.S. Army Research Institute conducts research on manpower, person-
nel, and training issues of particular significance and interest to the U.S.
Army. Every 4 years the President establishes a Quadrennial Review of Mili-
tary Compensation (QRMC) to study important military compensation issues.
This research was conducted in support of the Sixth QRMC. The relative cost
effectiveness of 3-year and 6-year reenlistment bonuses is measured.


Procedure:

     A relatively new statistical procedure called empirical Bayes was used to
analyze the relative effectiveness of 3-year and 6-year reserve reenlistment
bonuses. Adjustments were made to account for the fact that many reservists
would have reenlisted even if there were no reenlistment bonuses at all.


Findings:

     Reenlistment bonuses significantly affect the average length of commit-
ment of reservists. In addition, reservists who receive bonuses tend to have
lower attrition rates than those who do not, and 6-year reenlistment bonuses
are more cost effective than 3-year reenlistment bonuses.


Utilization of Findings:

     The results of this study may be used by the Sixth QRMC as part of its
examination of the relative effectiveness of reserve incentive programs. The
empirical Bayes method may also be applied to future research in which the
existing data bases are small or incomplete.

THE EFFECTS OF BONUSES ON ARMY RESERVE REENLISTMENTS: AN EMPIRICAL BAYES
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# THE EFFECTS OF BONUSES ON ARMY RESERVE REENLISTMENTS:
## AN EMPIRICAL BAYES APPROACH

## INTRODUCTION

The reserves have become an increasingly important part of the total Army (Enns, 1985), so the President's Sixth Quadrennial Review of Military Compensation (Sixth QRMC) will place special emphasis on reserve compensation issues. This paper was written in support of the Sixth QRMC. We examine here the role of Army Reserve reenlistment bonuses in determining the average reenlistment term, or "length of commitment" of reservists.

Army Reserve compensation issues initially gained attention after the end of the draft in 1973. Faced with increasing shortfalls in some areas and overages in others, in 1976 the President directed the Pentagon to undertake a comprehensive study of reserve compensation. That was the first time such a study was ever done (Department of Defense, 1978). Their report made numerous recommendations for modifications to the methods of paying reservists, but few of the recommendations were adopted.

In 1977 Congress authorized $5 million to evaluate the effect of bonuses on reenlistments into the Army National Guard and Army Reserve. Nonprior service reservists were offered bonuses of $1,800 for a 6-year reenlistment and $900 for a 3-year reenlistment. One-half of the bonuses were paid at the time of reenlistment and the remaining amount in $150 installments at the end of each obligated year of service. The Rand Corporation designed the bonus test and conducted a follow-up (Grissmer, Doering, & Sachar, 1982; Grissmer, Burright, Doering, & Sachar, 1982; Grissmer & Hiller, 1985).

Bonus payments were offered in six National Guard states and four Army Reserve regions. For each of those, a matching state or region was used as a control and did not offer bonus payments. A total of 15,000 guardsmen and reservists, each of whom reached the end of his term of service (ETS) in 1978, took part in the test and control states and regions. Researchers monitored the reenlistment decisions of all 15,000 and asked each to complete a questionnaire at the time of his decision.

The Rand study of the 1978 reenlistment bonus test concluded that bonuses had little effect on the reenlistment rates of reservists. That result was consistent with the results obtained by Kirkland, Raney, and Hicks (1984, p. 84), who surveyed reservists and found no consistent relationship between hypothetical reenlistment bonuses and intentions to reenlist. The Rand study did, however, find that bonuses significantly affect the average length of commitment of reservists. In addition, reservists who receive bonuses tend to have lower attrition rates than those who don't, indicating that bonuses might not increase the number of people reenlisting, but they would increase the number of committed man-years of service.

The Rand study concluded that without reenlistment bonuses there is little incentive for reservists to reenlist for more than 1 or 2 years at a time, even if their initial intention is to serve for a longer period. Subsequently, they may have marital or career changes that cause them to alter

their plans, so they do not serve in the reserves as long as originally intended. On the other hand, if reservists receive reenlistment bonuses they are more likely to honor their commitments, even in the face of unanticipated changes in their personal lives and careers. We can model this type of behavior using a relatively new statistical technique called empirical Bayes. The method is potentially very fruitful for using measured intentions to predict ultimate actions.

## AN EMPIRICAL BAYES MODEL

There have been a number of attempts to predict the enlistment and reenlistment behavior of military personnel from their stated intentions. Orvis (1982) and Orvis and Gahart (1985) applied ordinary least squares (OLS) models to several sets of survey data. They concluded that there is a systematic relationship between a person's stated intent to enlist in the military and his actual likelihood of enlisting. Nord, Schmitz, and Weiland (1986) used logistic regressions and data from the National Longitudinal Survey (NLS), and concluded that intention to enlist, measured at age 17, was the best single predictor of actual enlistment.

In this paper we use a behavioral model developed by Morrison (1979), who modeled the relationship between intentions and actual purchases of consumer goods. We assume that when a soldier signs a reenlistment contract his length of commitment, or "stated intent" for a term of reenlistment can be modeled by a binomial random variable with $n = 6$ years and $p = I_t$, the expected duration of service, or "true intent," so that

$$I_s = \text{Binomial } (n, p) \tag{1}$$

Intuitively, this means that the soldier responds binomially--yes or no, which is equivalent to 0 or 1--for each year that he thinks about as a term for reenlistment. The model also specifies that the true intentions are drawn from a beta distribution with parameters a and b:

$$I_t = \text{Beta } (a, b), \ a \geq o, \ b, \geq o. \tag{2}$$

The bonuses are assumed to match the length of service commitment to the soldier's true intentions.

A considerable body of psychological literature over the last two decades has discussed the possibility that an extrinsic type of reinforcement (e.g., money) might cause a person to lose some of his intrinsic motivation for performing a task (Korman, 1974, p. 201). In that view bonuses might attract more soldiers who have a lesser "taste" for military service, and one might expect bonus recipients to have higher attrition rates than the control group. Our hypothesis is the simpler economic one--that without the bonuses there is simply no incentive to reenlist for more than 1 year, but if a soldier does get a bonus and reenlists for more than 1 year, he is then more likely to honor his commitment and the attrition rates will therefore be lower in the

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bonus group than in the control groups. The empirical Bayes method is one way of choosing between the psychological and economic hypotheses of motivations.

The model specified by equations (1) and (2) "may sound strange" (Casella, 1985, p. 86), but different forms of it have been used and justified in marketing and psychology literature. For example, Kalwani and Silk (1982) used a similar model to determine the predictive validity of intention measures for purchasing durable and packaged goods. The compound distribution of $I_S$ on $I_t$ is called the beta-binomial, or negative hypergeometric distribution. The probability distribution for a reenlistment commitment of x years is given by (Kendall and Stuart, Vol. 1, 1969, p. 146):

$$h(x) = \frac{1}{n+1} \frac{B(a + x, \ b + n - x)}{B(x + 1, \ n - x + 1) \ B(a,b)} \ , \quad x = 0,1,2,\ldots,n \tag{3}$$

where

$$B(a,b) = \int_0^1 x^{a-1} (1 - x)^{b-1} \ dx. \tag{4}$$

The mean of the distribution in (3) is

$$E(I_s) = \frac{na}{a + b} \ , \tag{5}$$

and the variance is

$$VAR(I_s) = \frac{nab(a + b + n)}{(a + b)^2(a + b + 1)} \ . \tag{6}$$

Using equations (5) and (6) and the actual average value of stated intentions $I_s$ we obtain the empirical Bayes estimate

$$I_t = \frac{a + b}{a + b + 1} \ \overline{I}_s + (1 - \frac{a + b}{a + b + 1}) \ I_s \ . \tag{7}$$

Arguments for the use of empirical Bayes models versus more traditional econometric models closely parallel the arguments for using standard Bayes models rather than maximum likelihood methods (see Kendall & Stuart, 1969, pp. 202-203). It should be noted, however, that empirical Bayes methods have been used successfully with data sets which are small and incomplete (Casella, 1985), and incomplete data sets are frequently encountered in studies of the reserves.

## RESULTS

Solving equations (1) through (7) above using the Rand reenlistment bonus data we obtain a mean reenlistment time for the bonus group of 4.37 years, with a variance of 2.02. The values of parameters a and b are 4.46 and 1.67, respectively, so equation (7) becomes

$$I_i^t = 3.7568 + .14031 I_i^s . \tag{8}$$

Equation (8) is the empirical Bayes estimate of a soldier's true length of reenlistment intention, based upon his stated intention.

The results of this analysis are summarized in Tables 1 through 3. Table 1 shows how the existence of a reenlistment bonus tripled the average length of commitment. Table 2 shows that bonuses not only increase the initial term of commitment, they also increase retention rates.

Several other interesting points are also illustrated in Table 2. The empirical Bayes estimate calculated from equation (8) is not close to the actual survival rate for soldiers who initially extended for only 1-year extensions. It is possible that an entirely different model might need to be specified for the soldiers who don't receive a bonus. On the other hand the empirical Bayes estimates, which were calculated for the bonus group, were remarkably close to the survival rates for 3-year and 6-year reenlistees. This lends support to the economic hypothesis that bonuses cause soldiers to react according to their true intentions, and that the negative hypergeometric model described previously gives a good picture of those intentions.

Note also that Table 2 shows the 3-year and 6-year reenlistees had higher survival rates in the bonus group than in the control group. This lends support to the view that bonuses cause soldiers to reenlist according to their true intentions, and that once committed they tend to honor their contracts, rather than have the same attrition rate as a group that did not receive bonuses. In this view the bonuses are really preventing "shrinkage," i.e., the difference between the control and bonus rates shown at the bottom of Table 2. Note that this is a very conservative estimate of the increased retention achieved by the bonuses, since the bonus group actually had a lower survival rate for 1-year extenders. Hence the bonus, not membership in the bonus group, was probably the cause of the higher retention rate of the 3-year and 6-year reenlistees in the bonus group.

The relative cost effectiveness of the reenlistment bonuses is shown in Table 3. Questions frequently arise as to how costly bonuses are, since many reservists would reenlist even without them. Table 3 is the cost of only the prevented "shrinkage" shown in Table 2, e.g., it assumes the bonuses bought only the difference between the 73.6% and the 81.1% survival rates of 6-year reenlistees. We were fortunate in this case to have actual survival rates available from the Rand bonus tests, so those rates were used in the cost-effectiveness calculations. If those data had not been available, we would have used the 76.7% figure, rather than the 81.1% figure in Table 2.

Table 1

Average Terms of Commitment

Reenlistment Bonuses Tripled the Committed Man-Years

| Initial Reenlistment Decision | Army Reserve | | Army National Guard | | Totals | |
|---|---|---|---|---|---|---|
| | Number | Man-Yrs | Number | Man-Yrs | Number | Man-Yrs |
| **Control Group:** | | | | | | |
| 1-Yr | 788 | 788 | 2,110 | 2,110 | 2,898 | 2,898 |
| 3-Yrs | 244 | 732 | 94 | 282 | 338 | 1,014 |
| 6-Yrs | 29 | 174 | 39 | 234 | 68 | 408 |
| Totals: | 1,061 | 1,694 | 2,243 | 2,626 | 3,304 | 4,320 |
| Averages: | 1.60 Man-Yrs | | 1.17 Man-Yrs | | 1.31 Man-Yrs | |
| **Bonus Group:** | | | | | | |
| 1-Yr | 89 | 89 | 351 | 351 | 440 | 440 |
| 3-Yrs | 244 | 732 | 315 | 945 | 559 | 1,677 |
| 6-Yrs | 472 | 2,832 | 911 | 5,466 | 1,383 | 8,298 |
| Totals | 805 | 3,653 | 1,577 | 6,762 | 2,382 | 10,415 |
| Averages: | 4.54 Man-Yrs | | 4.29 Man-Yrs | | 4.37 Man-Yrs | |

Raw Data Source: Grissmer, Doering, and Sachar (1982).

Table 2

Empirical Bayes Estimates

Reenlistment Bonuses Increased Retention Rates

| | At Start of Experiment: | | |
|---|---|---|---|
| Initial | % Reenlisting in Each Category | | |
| Reenlistment | Control | Bonus | |
| Decision | Group | Group | |
| 1-Yr | 87.5% | 18.2% | |
| 3-Yrs | 10.4 | 23.9 | |
| 6-Yrs | 2.1 | 57.9 | |
| | 100.0 | 100.0 | |

| | At End of Third Year of Experiment: | | |
|---|---|---|---|
| Initial | Number Remaining in Reserves | | |
| Reenlistment | Control | Bonus | Empirical Bayes |
| Decision | Group | Group | Estimate |
| 1-Yr | 57.4% | 45.0% | 65.0% |
| 3-Yrs | 72.9 | 76.2 | 69.7 |
| 6-Yrs | 73.6 | 81.1 | 76.7 |

Raw Data Source: Grissmer and Hiller (1985).

Table 3

Bonus Costs for Additional Man-Years

6-Year Bonuses Are the Most Cost Effective

| Initial Reenlistment Decision | Reenlistment Bonus | Current Dollars | Inflation Adjusted | Current Dollars | Inflation Adjusted |
|---|---|---|---|---|---|
| 3-Yrs | $900 | $594,900 | $575,135 | $7,331 | $6,747 |
| 6-Yrs | $1,800 | $2,727,300 | $2,580,729 | $4,584 | $4,337 |

"Inflation Adjusted" means constant 1986 dollars.

Costs in both current dollars and constant 1986 dollars, assuming a 4% annual inflation rate, are shown in Table 3. Bonuses for 6-year reenlistments are more cost effective than bonuses for 3-year reenlistments, possibly because the bonuses succeed in preventing reenlistment shrinkage from the most committed soldiers. In future studies an empirical Bayes estimate of the type shown in Table 3 may be used to project the survival rates of soldiers who accept reenlistment bonuses, which will aid in force structure projections.

## CONCLUSIONS

An empirical Bayes analysis of the 1978 Army Reserve reenlistment bonus test shows that reenlistment bonuses are a useful device for increasing the average reenlistment terms, or "committed man-years" of service (Table 1). Bonuses also increased Army Reserve retention rates (Table 2). Six-year bonuses are more cost effective than 3-year bonuses (Table 3).

Empirical Bayes estimates have been especially useful in applications where the existing data bases have been small or incomplete. The Sixth Quadrennial Review of Military Compensation (QRMC) may find those techniques useful as they study the compensation structure of the reserve components.

The statistical methods used in this paper can also be applied to making projections based upon analyses that the Sixth QRMC makes using newly collected data. Measures of lengths of commitments can be used for planning reserve force structure sizes several years into the future. An analysis of reenlistment rates by mental category would be a logical next step. Much of the literature on reserves (Brinkerhoff & Grissmer, 1984) concludes that reserve enlistment and retention rates are largely dependent upon noneconomic factors which cannot be easily quantified. Thus any methods, such as empirical Bayes, which can cast light on the exact value of the quantifiable monetary benefits should be very helpful to policymakers.

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